ISEO
Improving the lake Status from Eutrophy towards Oligotrophy

Overview of the main achievements of the research activities carried out by the UNIBS group

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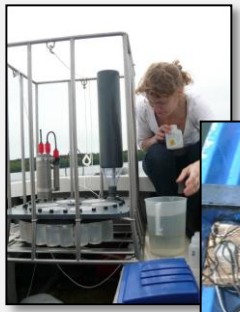
fondazione cariplo

18 June 2019, Brescia

General objective: quantitative assessment of local pressures on the overall P load to clarify how effective will external nutrient load reductions be on the trophic evolution of Lake Iseo.



P from the sediments in the anoxic area

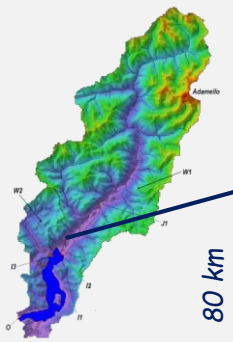
P from the main tributaries

Hydrodynamic and ecological modeling

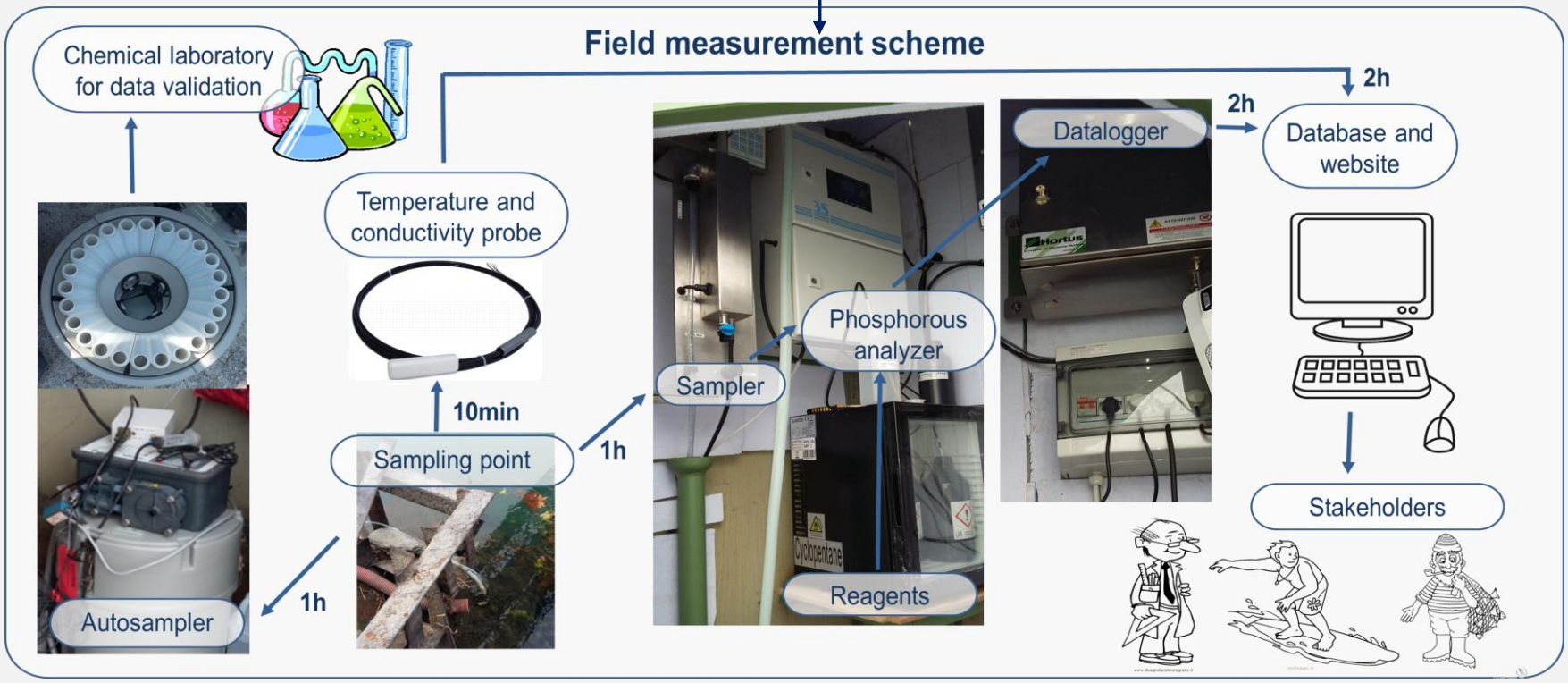
Role of the macrophytes in the shallower areas

P from the CSOWs

Objective: quantify the temporal variation of the incoming load.

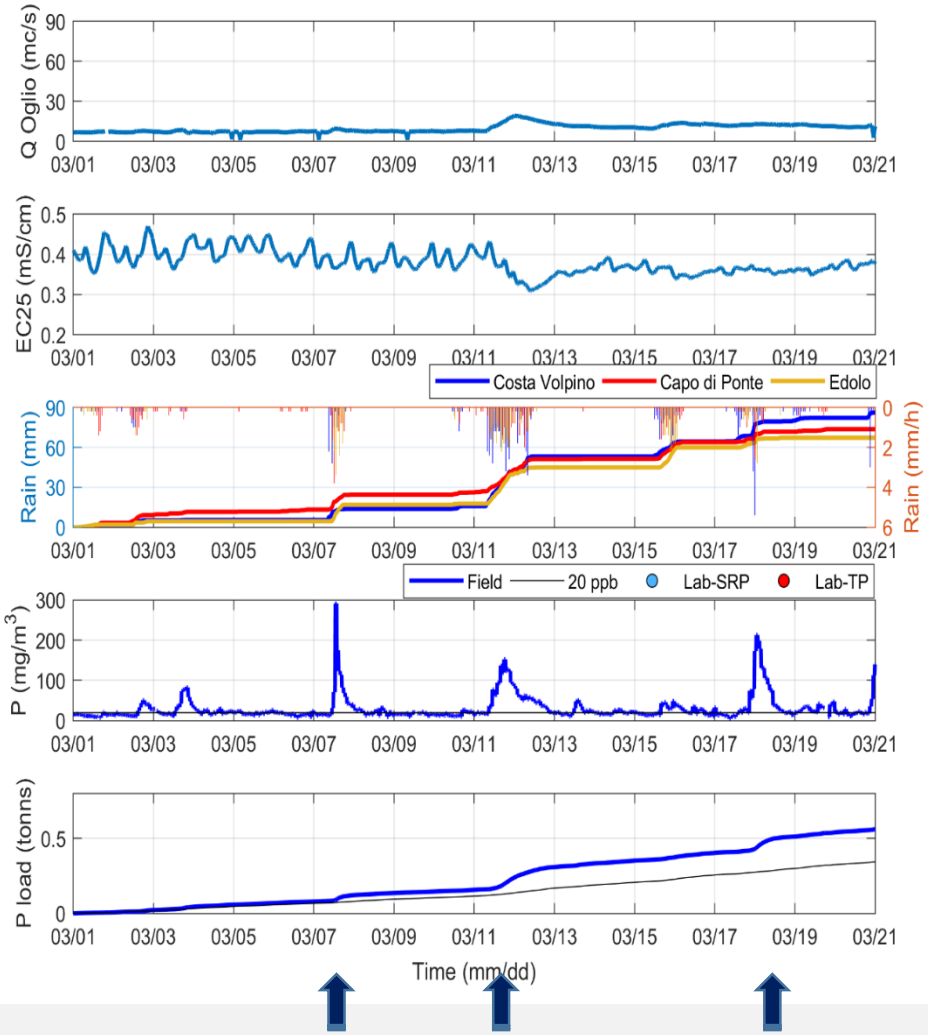


- ✓ 272 days of hourly data
- ✓ Widely varying hydrological conditions (rain/Q)
- ✓ 81 SRP data and 47 TP synchronous laboratory data

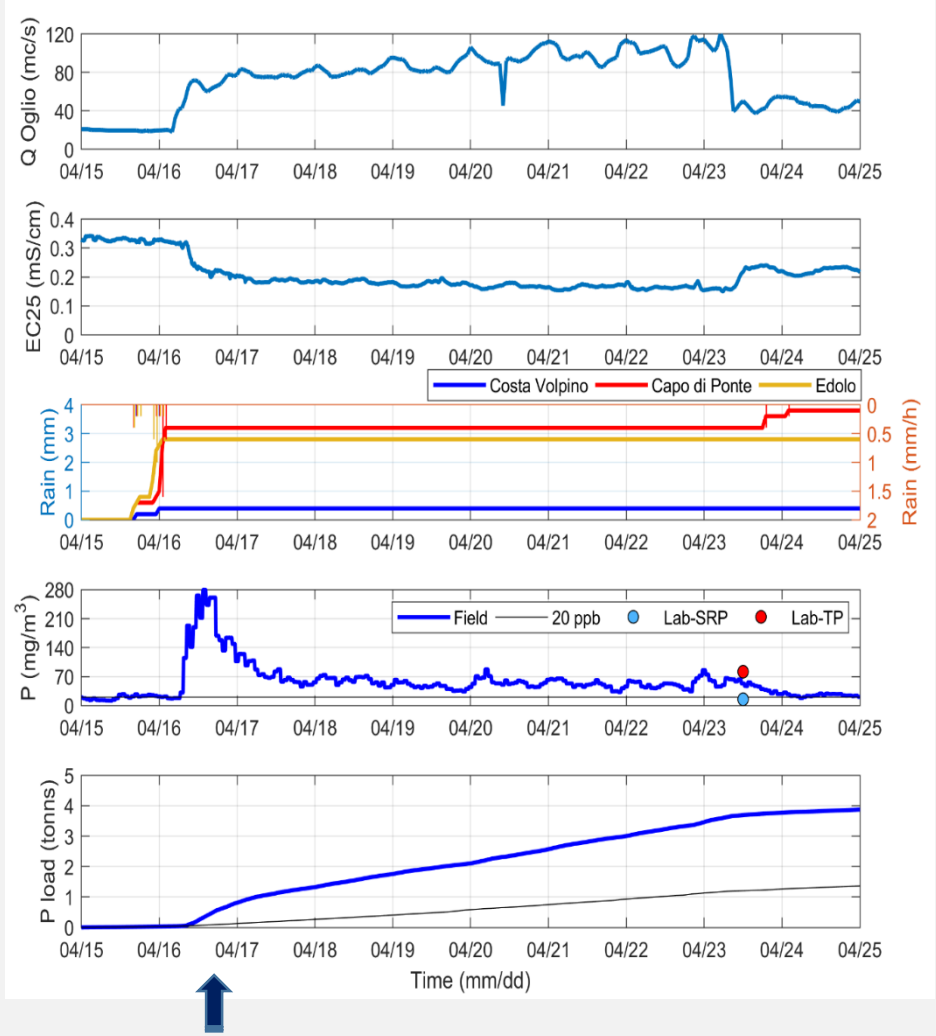


Results: 1) Two main reasons for P varibility: rain events and discharge increase.

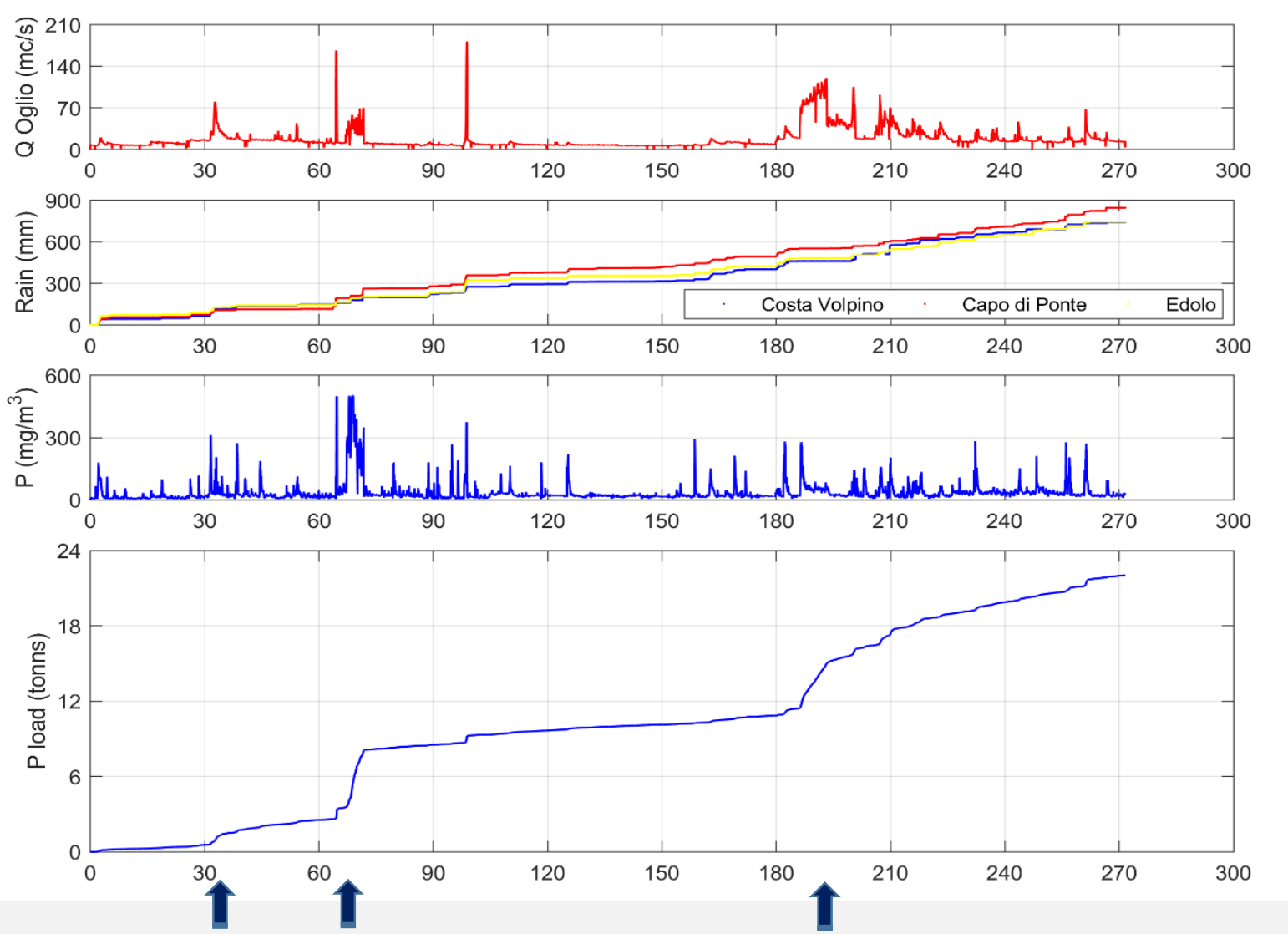
Rain event associated with low discharge



Wet period with high discharge

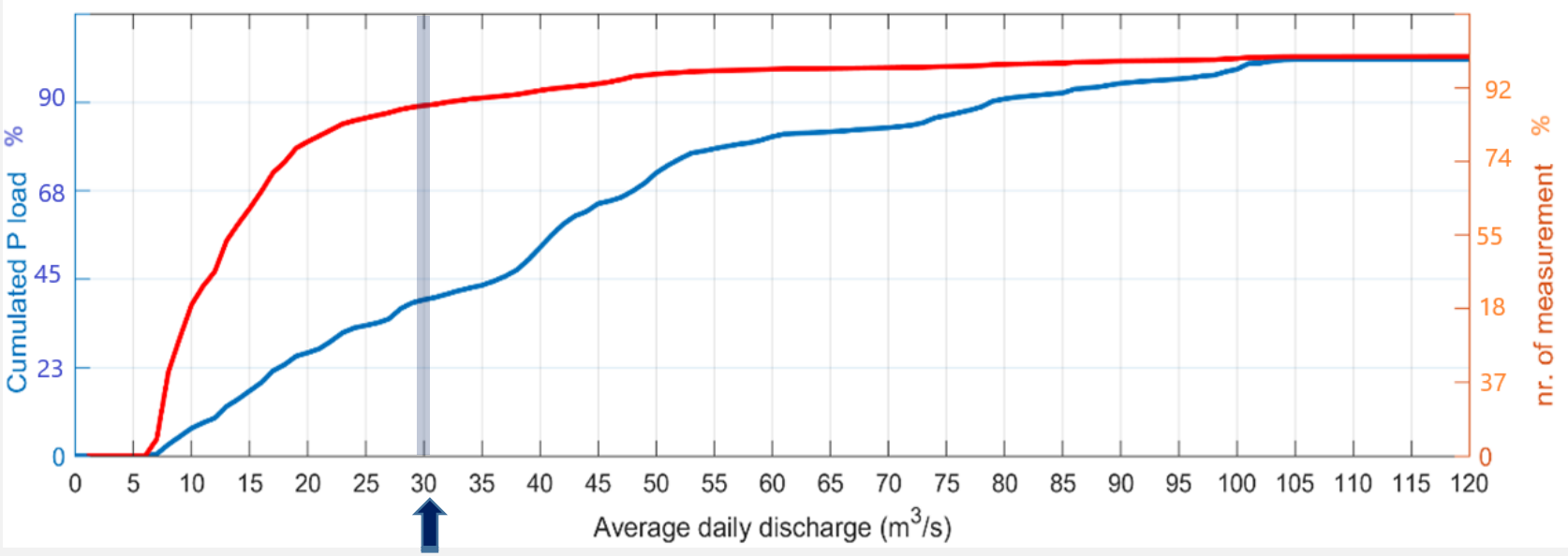


Results: 2) Large contribution of the high discharge events to the overall load.



Results: 2) Large contribution of the high discharge events to the overall load.

	Whole series	Dry periods	Q < 30 mc/s	Q < 60 mc/s
Nr. days	272	125.7	237.7	262.5
Nr. Days %	100%	47%	87%	97%
Cumulated load (t)	22.1	7.5	8.8	18.1
Yearly load (t/yr)	29.6	21.9	13.6	25.2
Load %	100%	74%	45%	85%

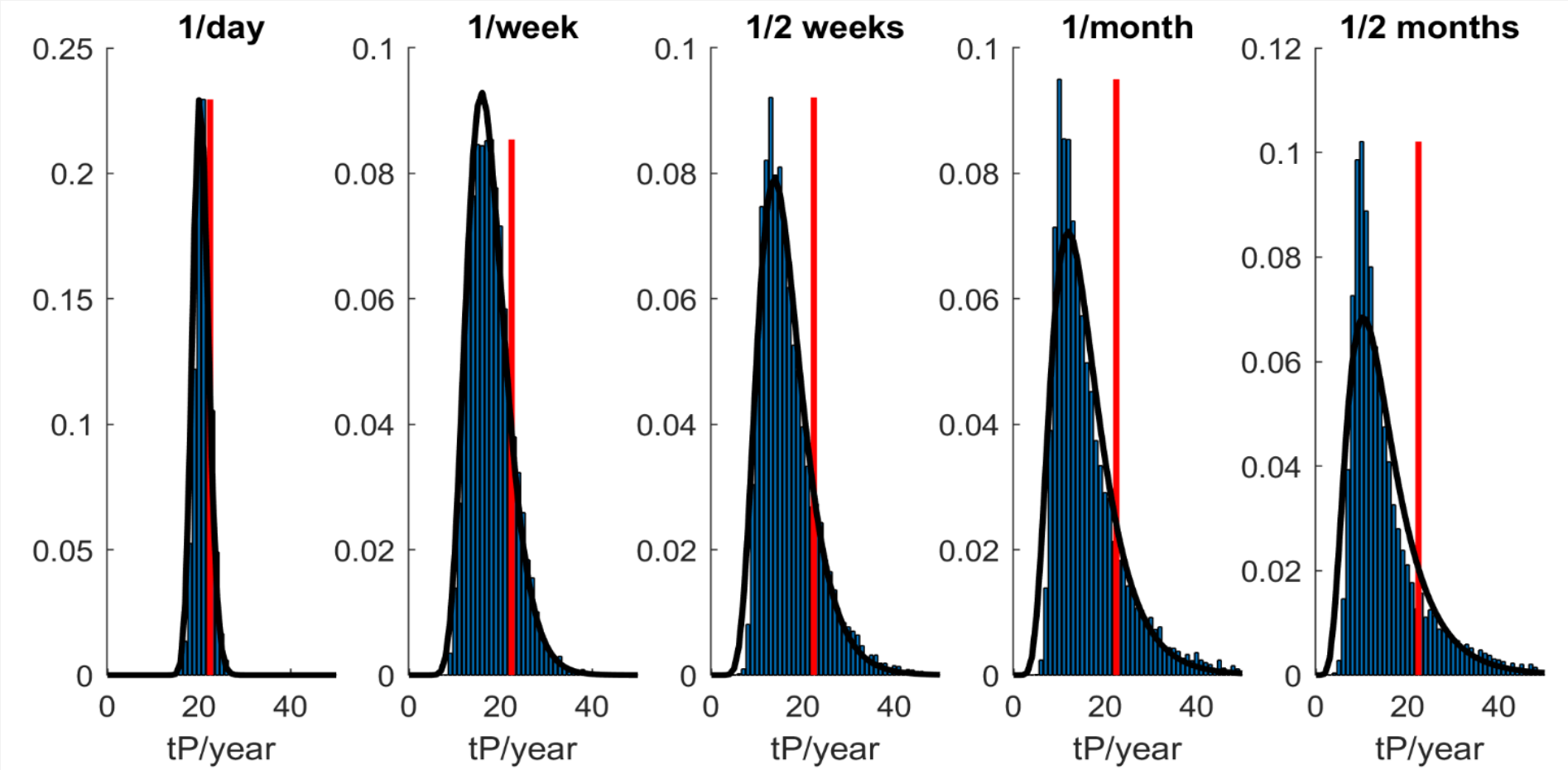


Cumulated P load from Oglio river (blue line, left y axis) and duration (red line, right y axis) during days with discharges lower than a given threshold.

Results: 3) Impact of the sampling frequency (f) on the load estimation

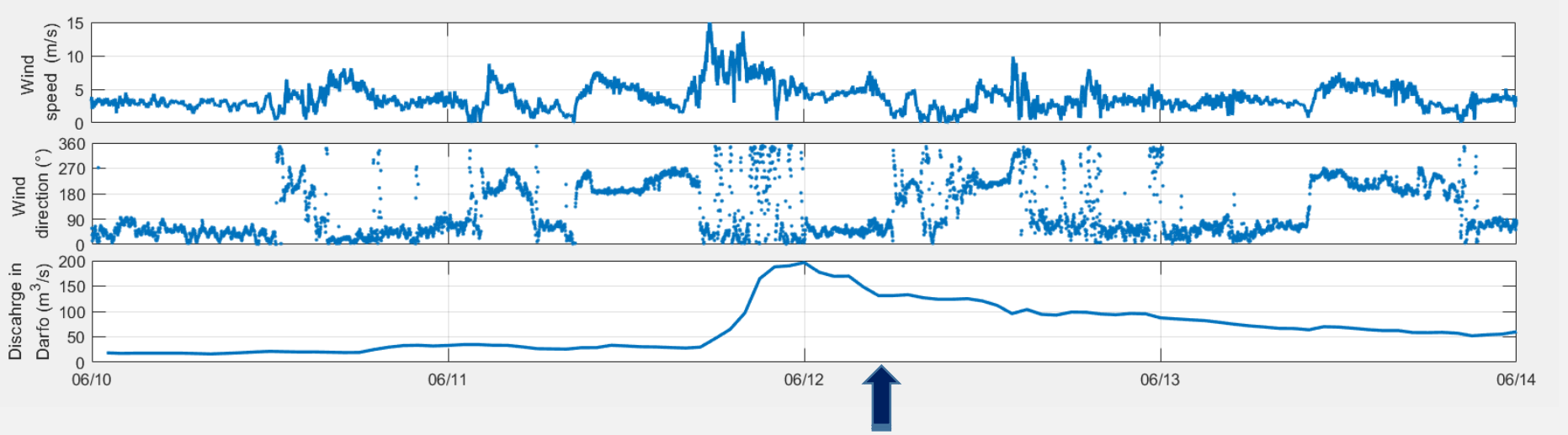
$$\text{Load} = \sum_{i=1}^{N} \int C_i q dt$$

with N = nr. of samplings in the investigated period



-10% **-28%** **-37%** **-46%** **-55%**

Results: 4) Interesting phenomena observed in the northern part of the lake by the webcam



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13/6/2019

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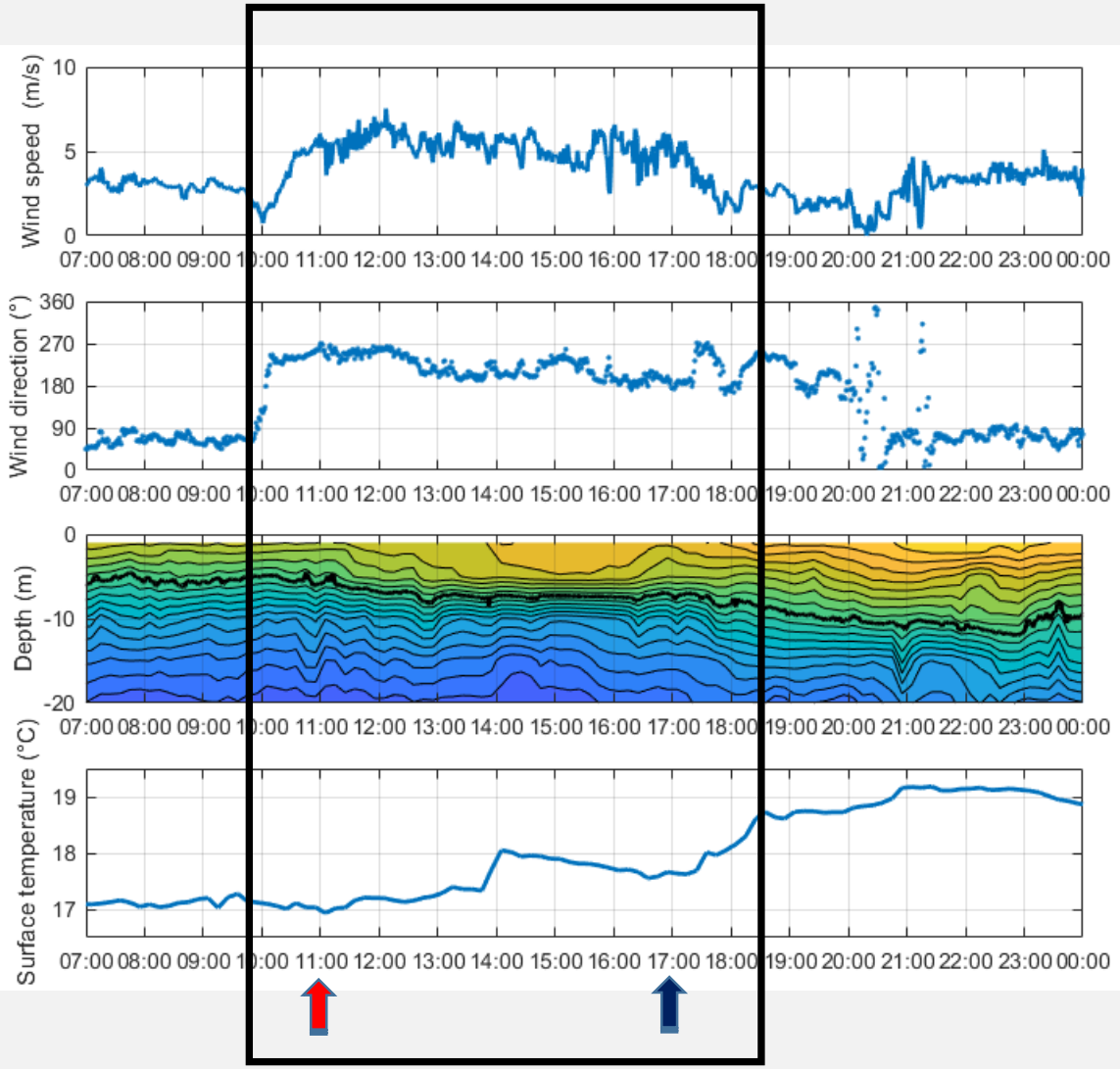


Results

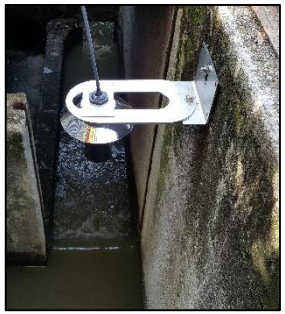
1) Two main reasons for P variability: rain events and discharge increase
2) Concentration of the P load in high discharge events
3) Questionable suitability of monthly data. We emphasize the need for event-focused water quality sampling (e.g. on the basis of given rain/Q thresholds)

Pilotti, M., Valerio, G., Giardino, C., Bresciani, M., Chapra, S.,(2018). *Evidence from field measurements and satellite imaging of impact of Earth rotation on Lake Iseo chemistry*, Journal of Great Lakes Research, 44, 14–25.

Remaining issues / future work

1) Difficulty in giving an interpretation of the measured quantity (in between the lab. SRP and TP), making this series unsuitable for an overall load estimation.
2) To what extent does the particulate P contribute to the SRP in the lake?
3) Lack in measuring the P variability in the Canale industrial
4) Need to integrate these results with the one achieved by Parma and related paper
5) Validation of surface currents of 3D models with the webcam images / satellite images

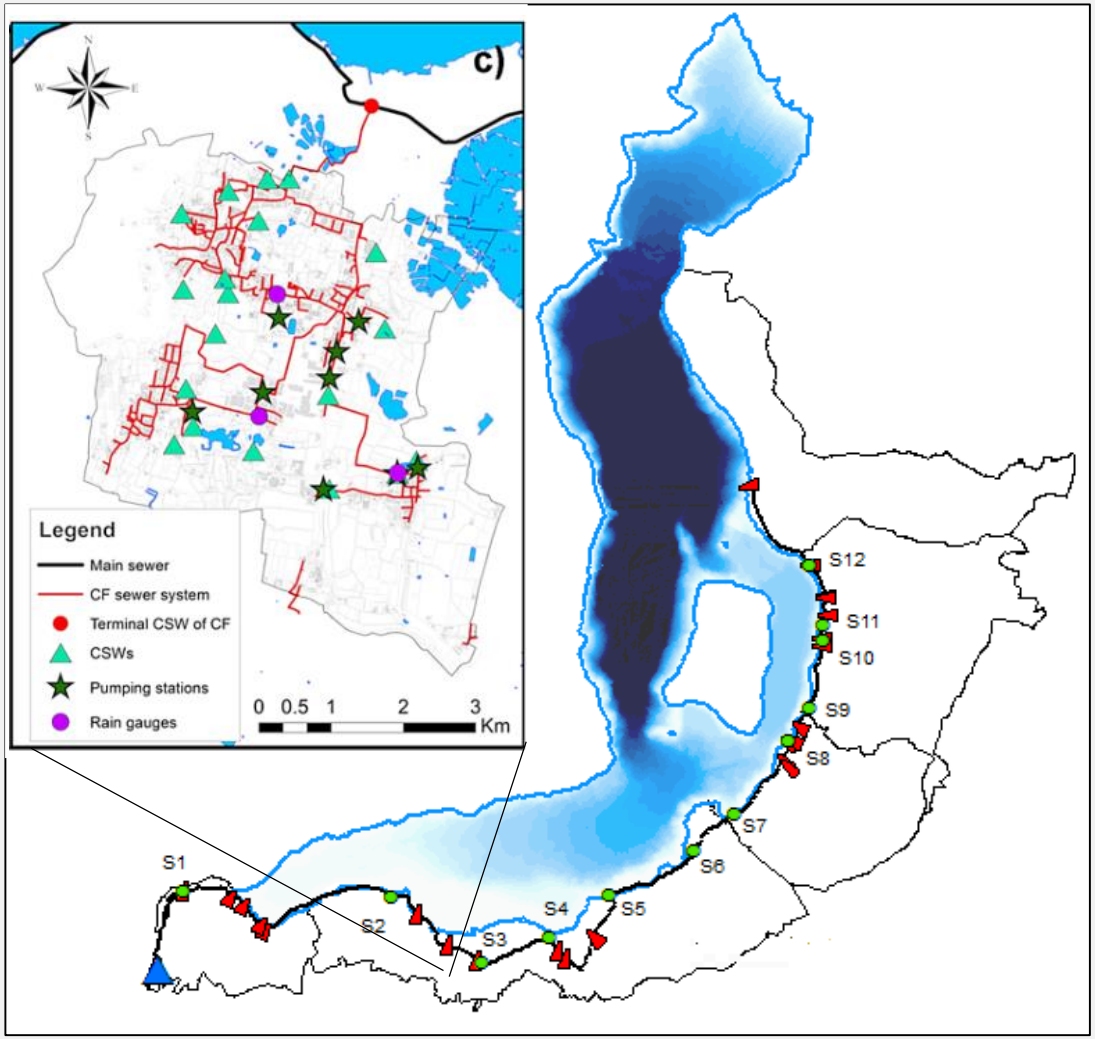
Objective: quantify the phosphourous load from the CSOWs



2017-2018

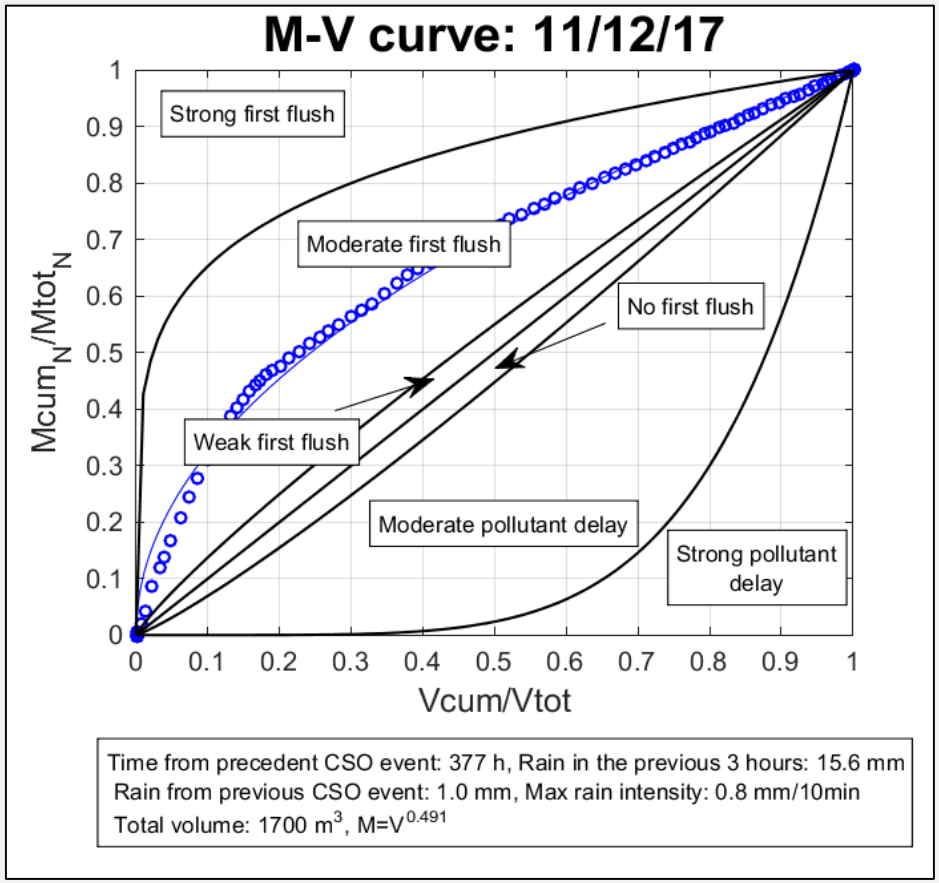
- ✓ Chemical characterization of 18 overflows events in the Cortefranca CSO (242 samples)
- ✓ Chemical characterization of 10 overflows events in the Paratico CSO (107 samples)
- ✓ Hydraulic monitoring of the incoming ond overflowing discharges in the CSOs of Cortefranca, Provaglio and Paratico

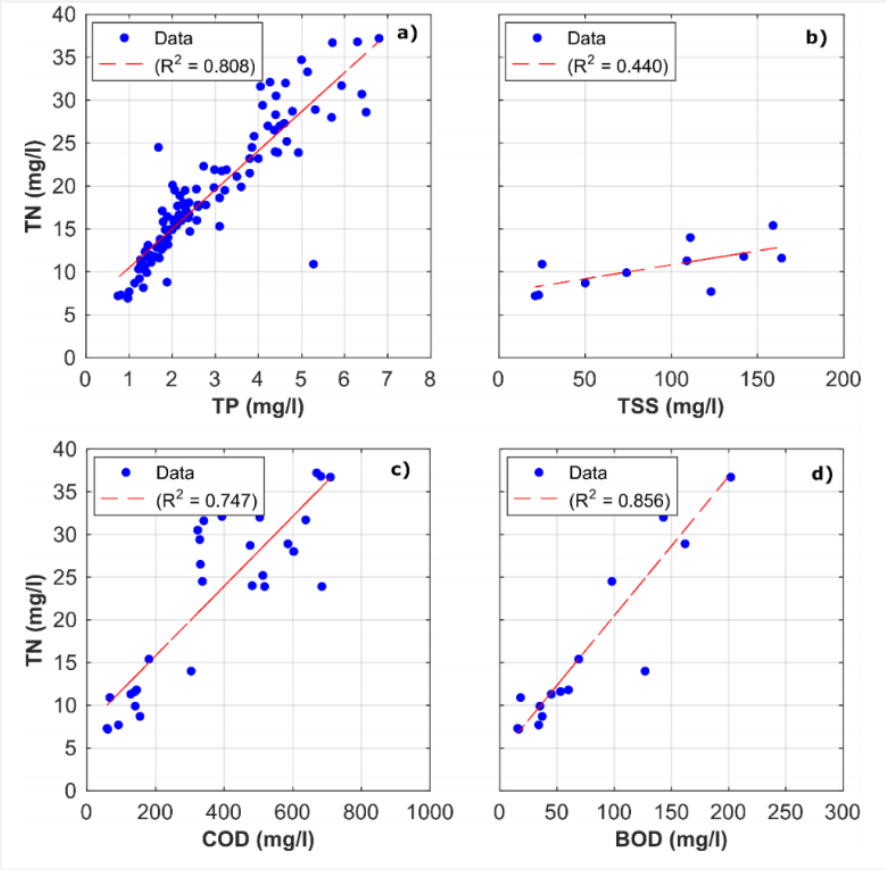
Objective: quantify the phosphourous load from the CSOWs



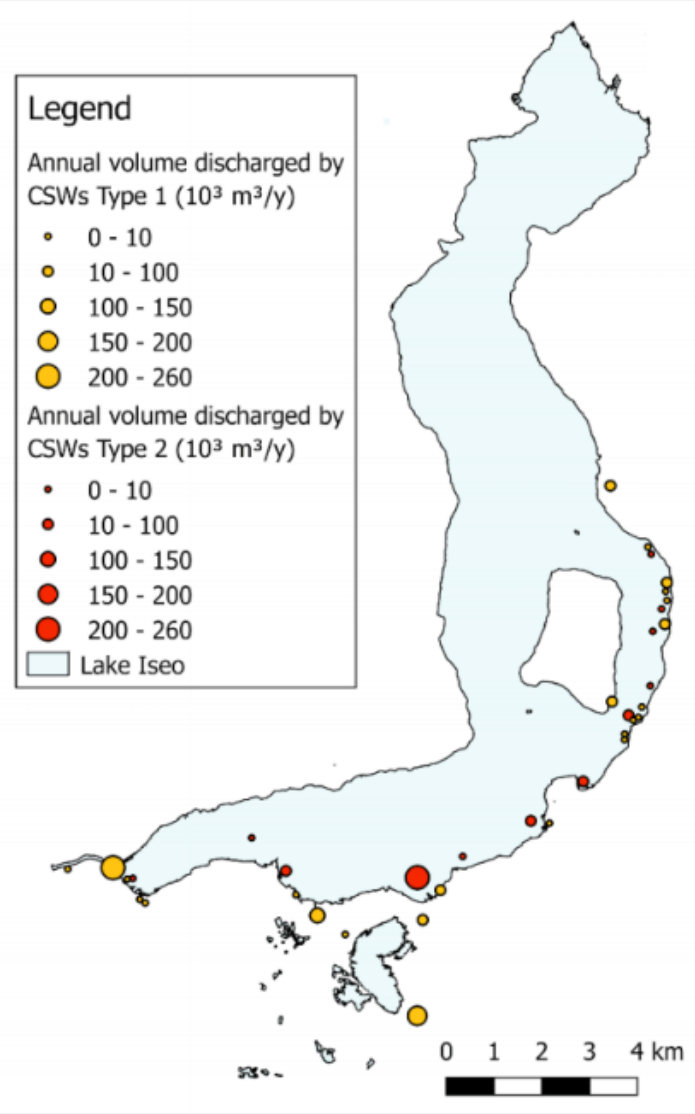
- ✓ Hydraulic model of the CSOWs
- ✓ 10 years hydraulic and hydrological model of the Cortefranca and Provaglio municipal sewage network
- ✓ 10 years hydraulic and hydrological model of the whole Brescia main collector, including a model of the infiltrations
- ✓ Statistical analysis of the measured data to extrapolate them to the whole network

Results: 1) Moderate-weak first flush in CF, whose strength is significantly correlated with the duration of the antecedent dry-weather period; good TN/TP correlation





Results: 2) Quantification of the role of the CSOs on the overall TP load to the lake



Volumes	10^3mc/year	1˙210
Efficiency	% of treated volumes	81%
Role of infiltration	% of volumes discharged to the lake	17%
TP load	t/year	3.445
Efficiency	**% of untreated P**	**13.1%-21.8%**
TN load	t/year	21.758
Efficiency	% of untreated N	20.7%-41.4%

Results

1) Moderate-weak first flush in the municipal CSO

2) Residual load from the the CSOWs of 3.5 t TP/year, favoured by sedimentations in the dry periods and by the infiltrations in the pipes

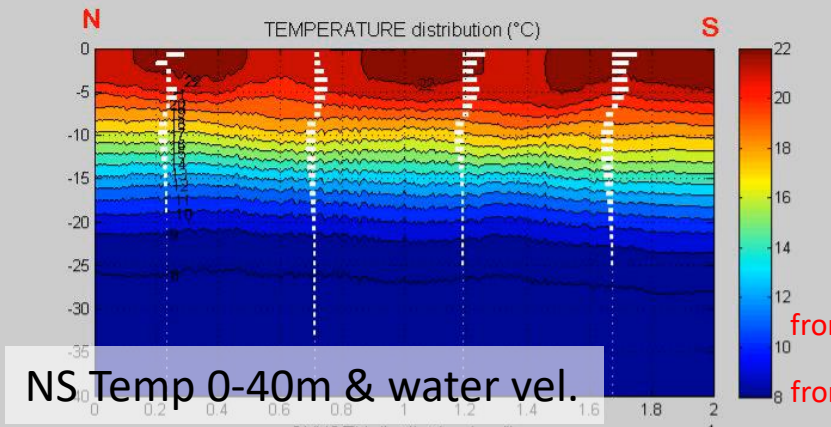
Barone, L., Pilotti, M., Valerio, G., Balistrocchi, M., Milanesi, L., Chapra, S. and Nizzoli, D. (2019) *Analysis of the residual nutrient load from a combined sewer system in a watershed of a deep Italian lake*, Journal of Hydrology, 571, 202-213, https://doi.org/10.1016/j.jhydrol.2019.01.031

Remaining issues / future work

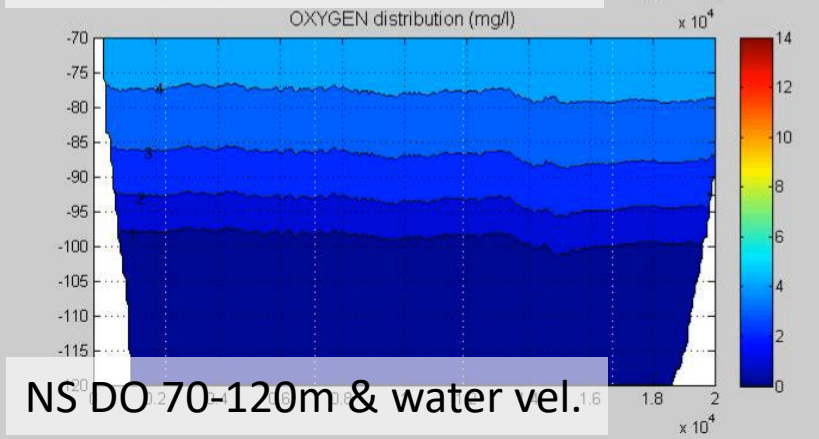
1) To what extent does the particulate P contribute to the SRP in the lake assimilated by the algae?

2) Extension of these results to the eastern side of the lake

Objective: Determine possible reasons for the temporal variability of the nutrient fluxes from the bottom sediments – alternating currents and redox conditions



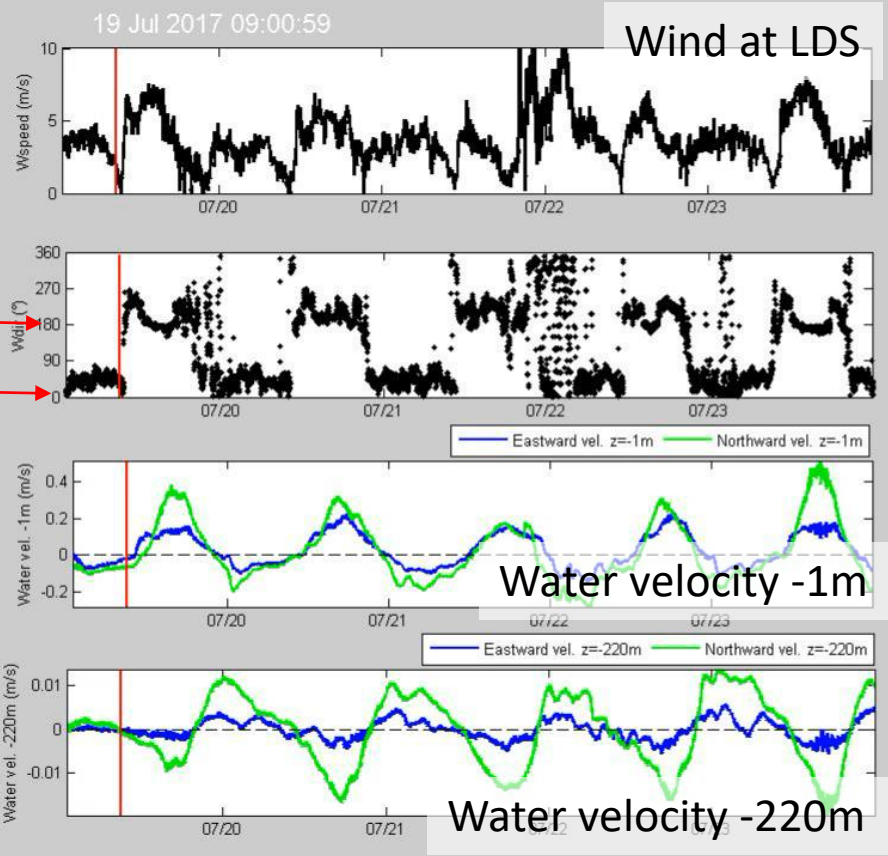
NS Temp 0-40m & water vel.



NS DO 70-120m & water vel.

fromS

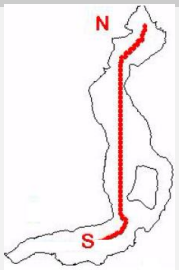
fromN

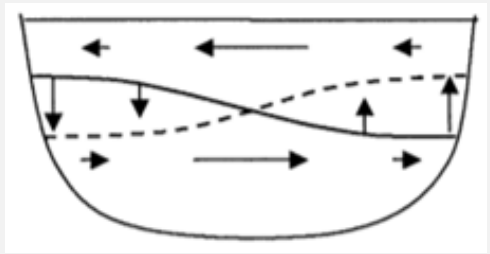


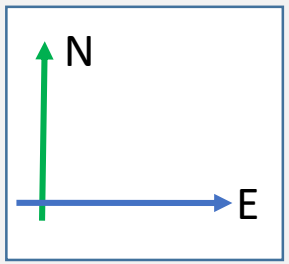
Wind at LDS

Water velocity -1m

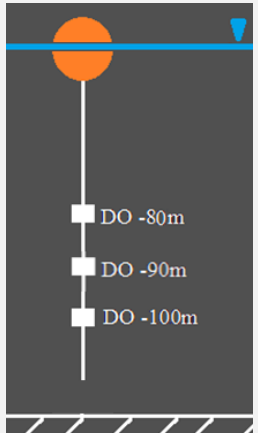
Water velocity -220m

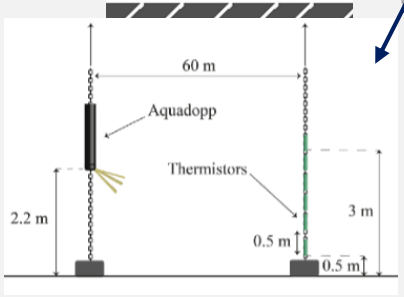


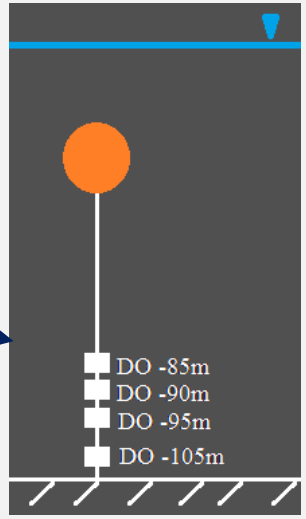




Objective: Determine possible reasons for the temporal variability of the nutrient fluxes from the bottom sediments – alternating currents and redox conditions







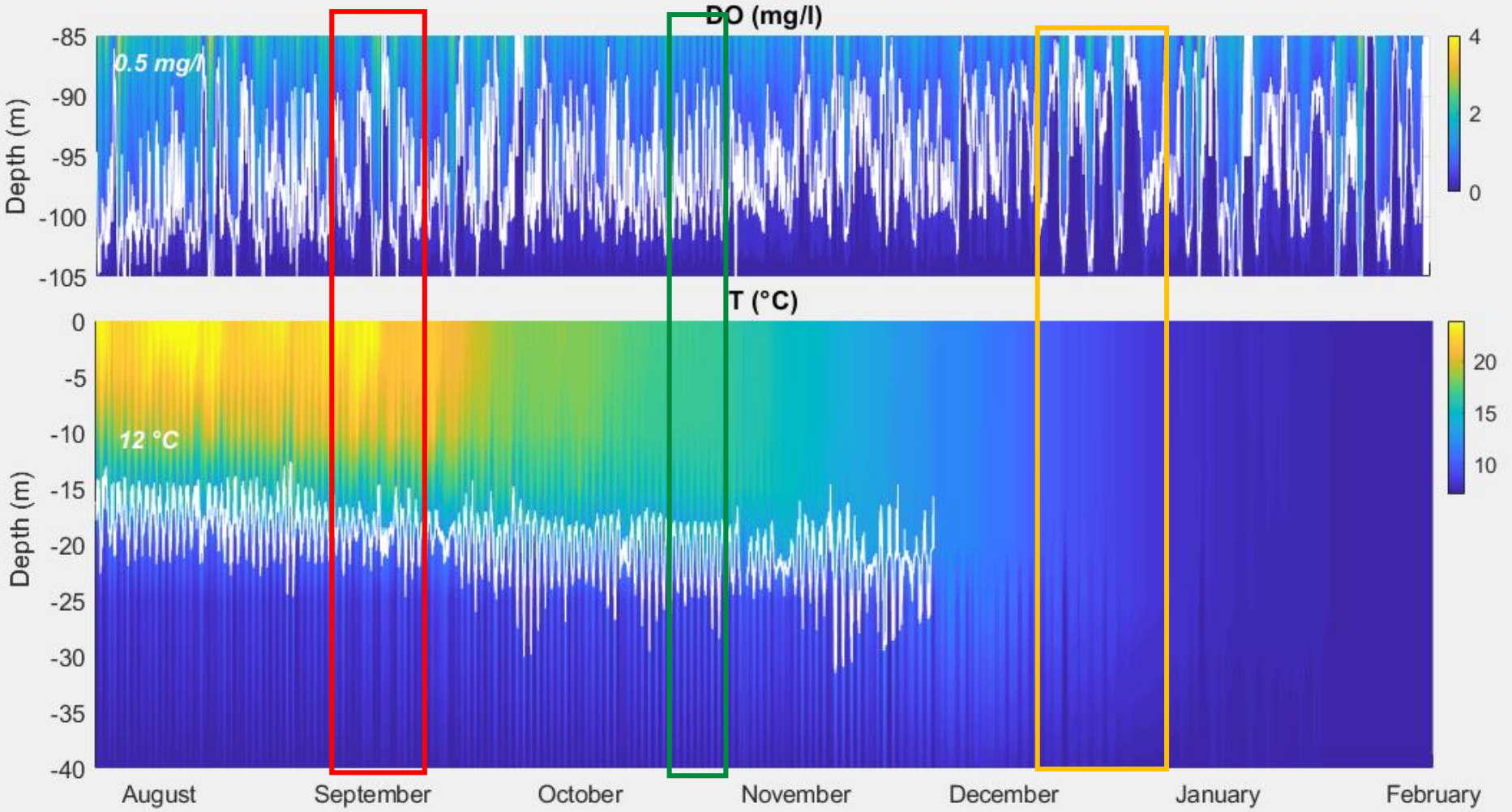
- ✓ 1-year-long DO measurements in two lakes positions at the oxycline depth (1/min)
- ✓ Continuous meteo and water temperature monitoring at LDS (1/min)
- ✓ 4 days field campaing profiling DO at the N and S basins
- ✓ Quantification of the density difference across the chemocline
- ✓ Numerical model of the deep internal waves structure
- ✓ 1 month ADCP measurement

Results: 1) Evidence of periodic and large oxycline oscillations driven by wind

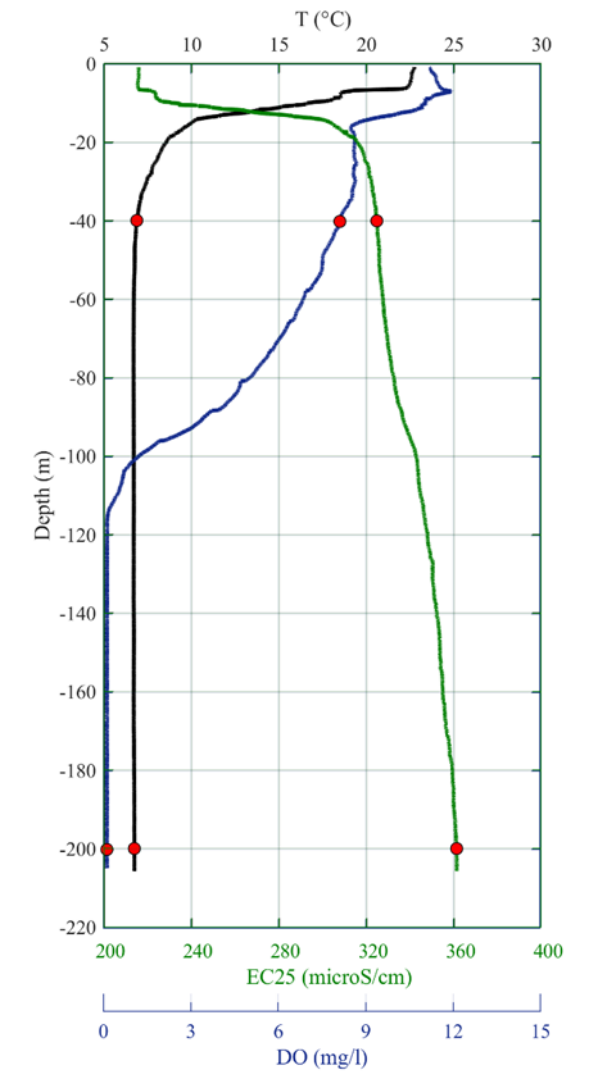
Decoupled V2H1 mode driven by long lasting winds

Coupled V1H1 mode driven by ordinary winds

Deep V1H1 mode supported by the chemical gradient (*)

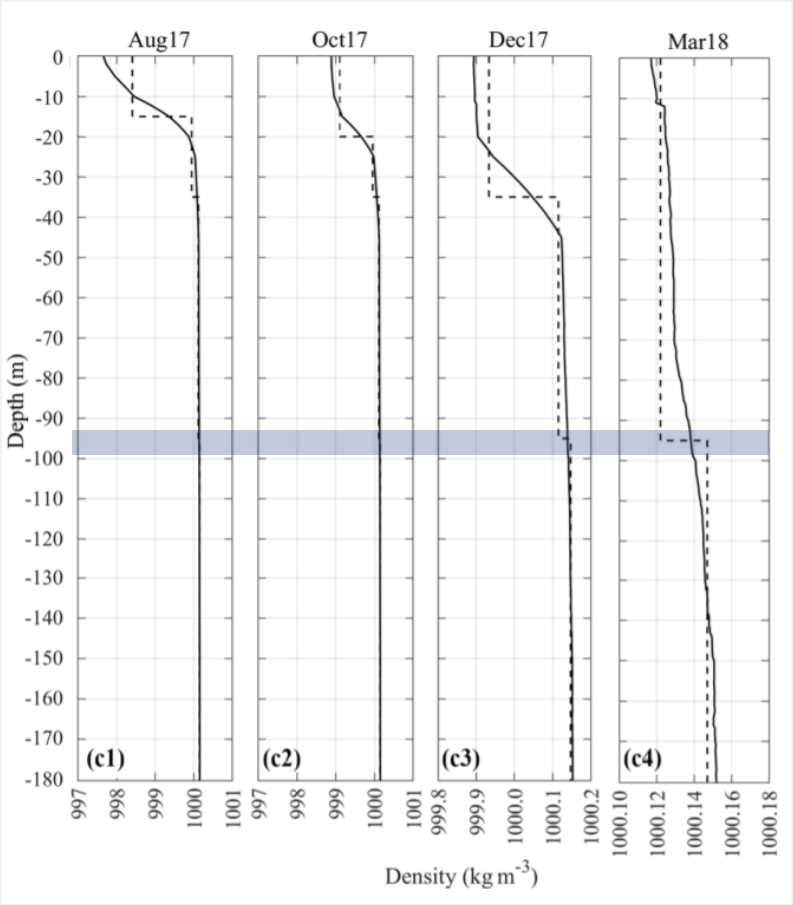


Results: 2) The chemocline supports / enhances these oscillations



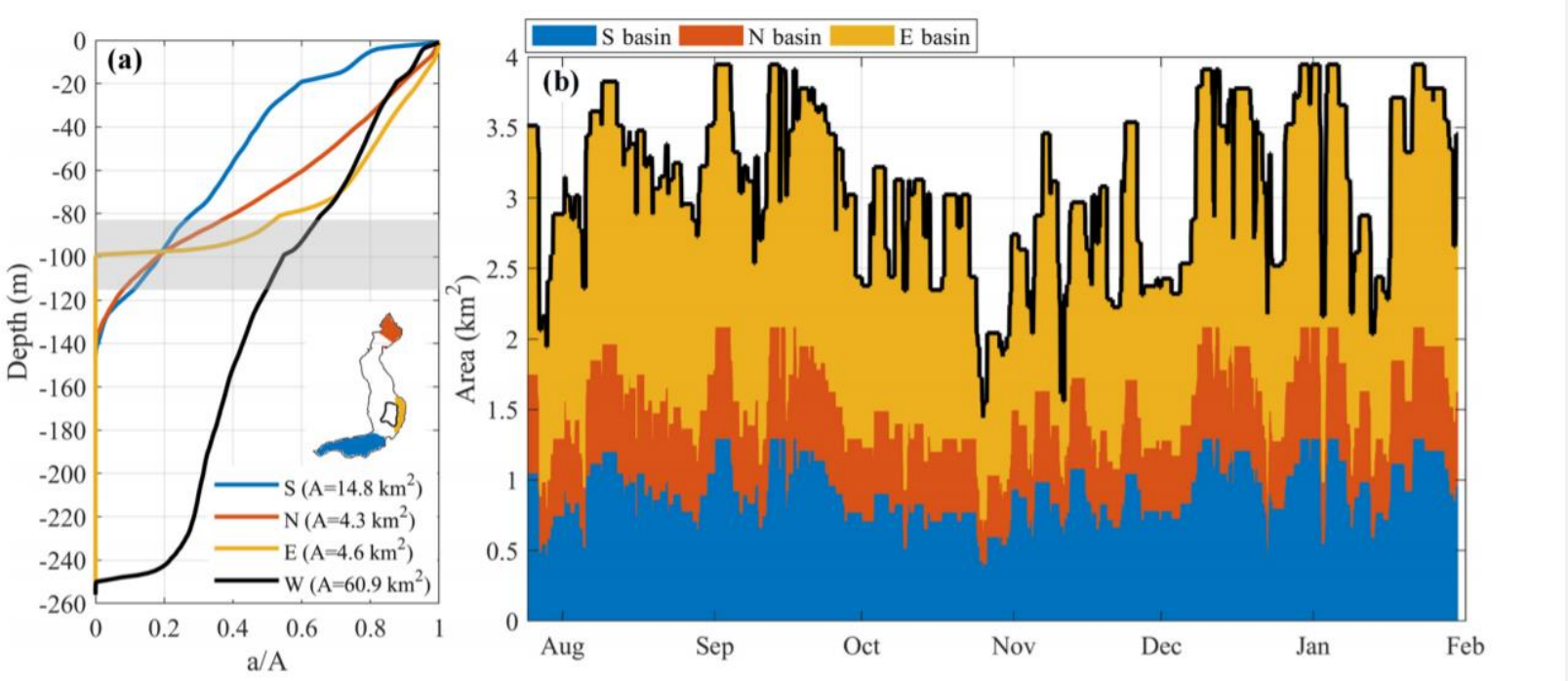
	z = 40	z = 200 m
Na^+ (mg/l)	3.5	3.5
K^+ (mg/l)	1.2	1.3
NH_4^+ (mg/l)	< 0.05	0.22
Ca_2^+ (mg/l)	42.7	49
Mg_2^+ (mg/l)	10.1	11.2
Mn_2^+ (mg/l)	< 0.005	0.241
Fe_2^+ (mg/l)	< 0.02	0.027
Al_3^+ (mg/l)	< 0.02	< 0.02
Cl^- (mg/l)	3	3
F^- (mg/l)	0.2	0.2
NO_3^- (mg/l)	4	< 1
HCO_3^- (mg/l)	127	142
CO_3^{2-} (mg/l)	< 5	< 5
SO_4^{2-} (mg/l)	48	54
H_4SiO_4 (mg/l)	3.8	6.9
DOC (mg/l)	0.8	0.8
pH (-)	7.9	7.6
T (°C)	6.86	6.72
K25 (μScm^{-1})	324.73	361.20
DO (mg/l)	8.11	0.12

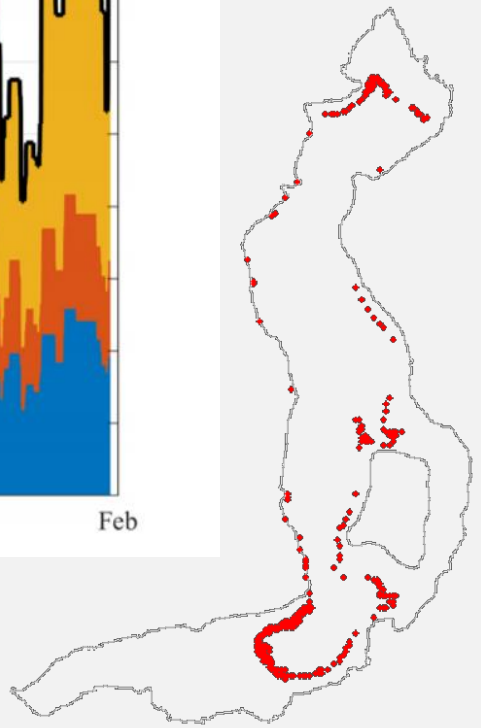
$\Delta\rho$ = 25 mg/l



2-4 layers stratification

Results: 3) 3 % of the lake's sediment area subjected to oxygen fluctuations 0-3 mg/l





Results

1) Large oxycline oscillations driven by the internal waves and supported by the presence of 25 mg/l of density difference at the chemocline

2) 3 % of the lake's sediment area subjected to oxygen fluctuations 0-3 mg/l

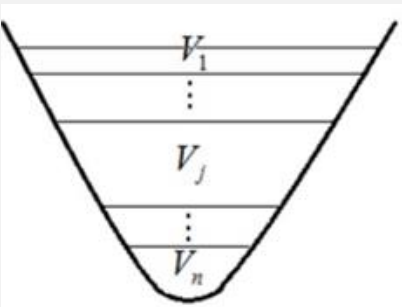
Valerio, G., Pilotti, M., Lau, M.P. and Hupfer, M., (2019). *Oxycline oscillations induced by internal waves in deep Lake Iseo*, Hydrol. Earth Syst. Sci., 23, 1763-1777, https://doi.org/10.5194/hess-23-1763-2019.

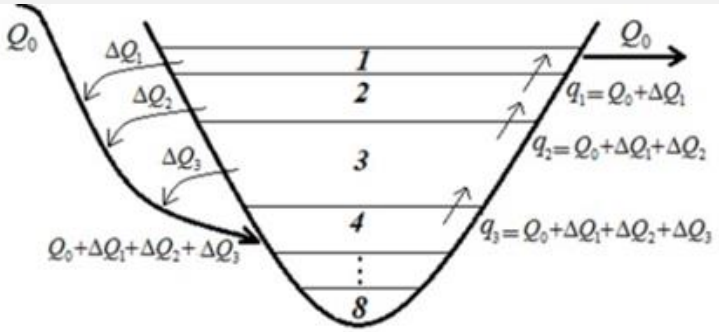
Remaining issues / future work

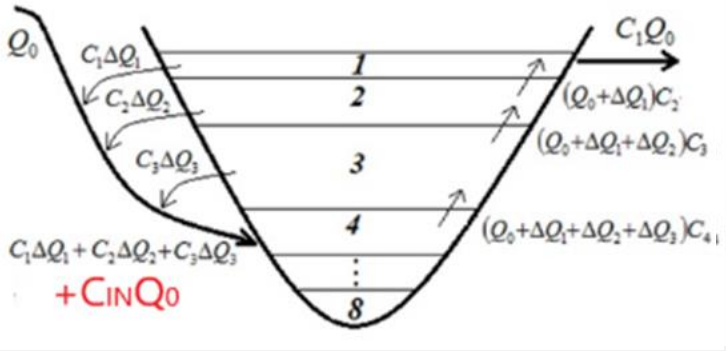
1) Effects of alternation bottom currents measured by IGB at the lake bottom on the nutrient fluxes

2) Quantification of the effect of variable redox conditions above the sediments on the nutrient fluxes

Objective: Model the effect of the different nutrient sources on the P evolution in the lake (in progress)

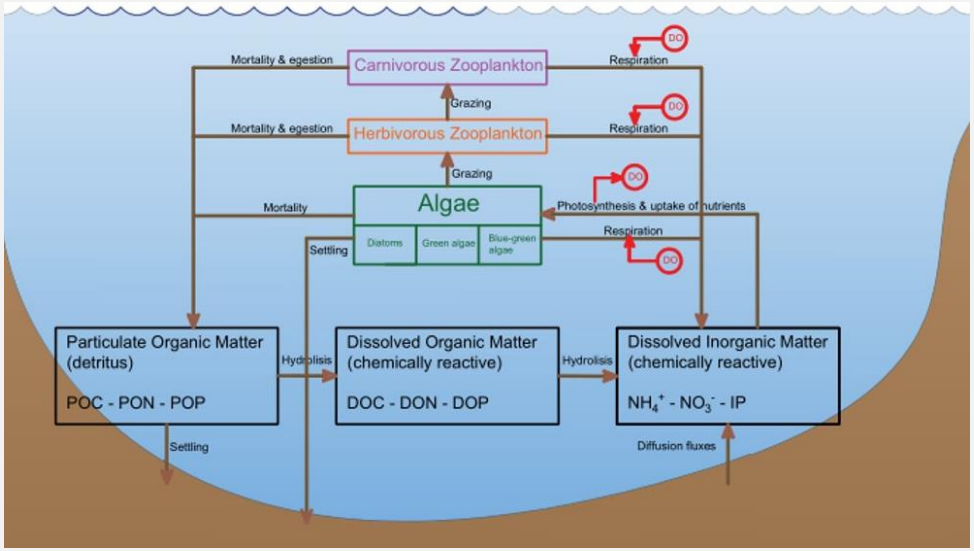


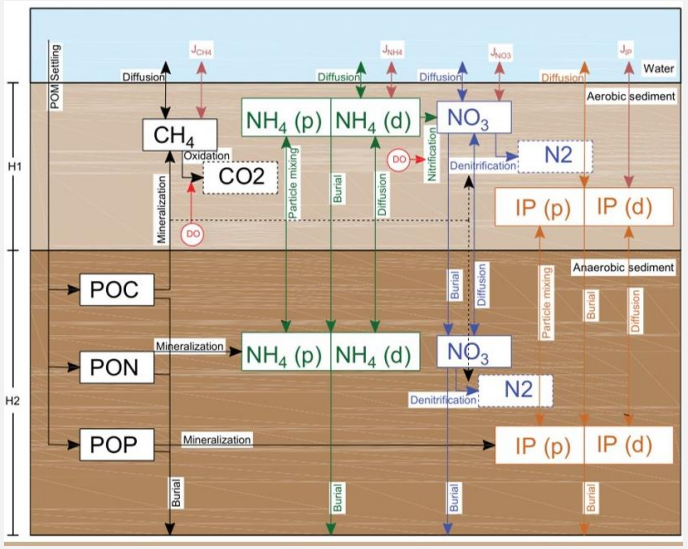




Pilotti et al. 2014 WRR

Water column model + sediment model

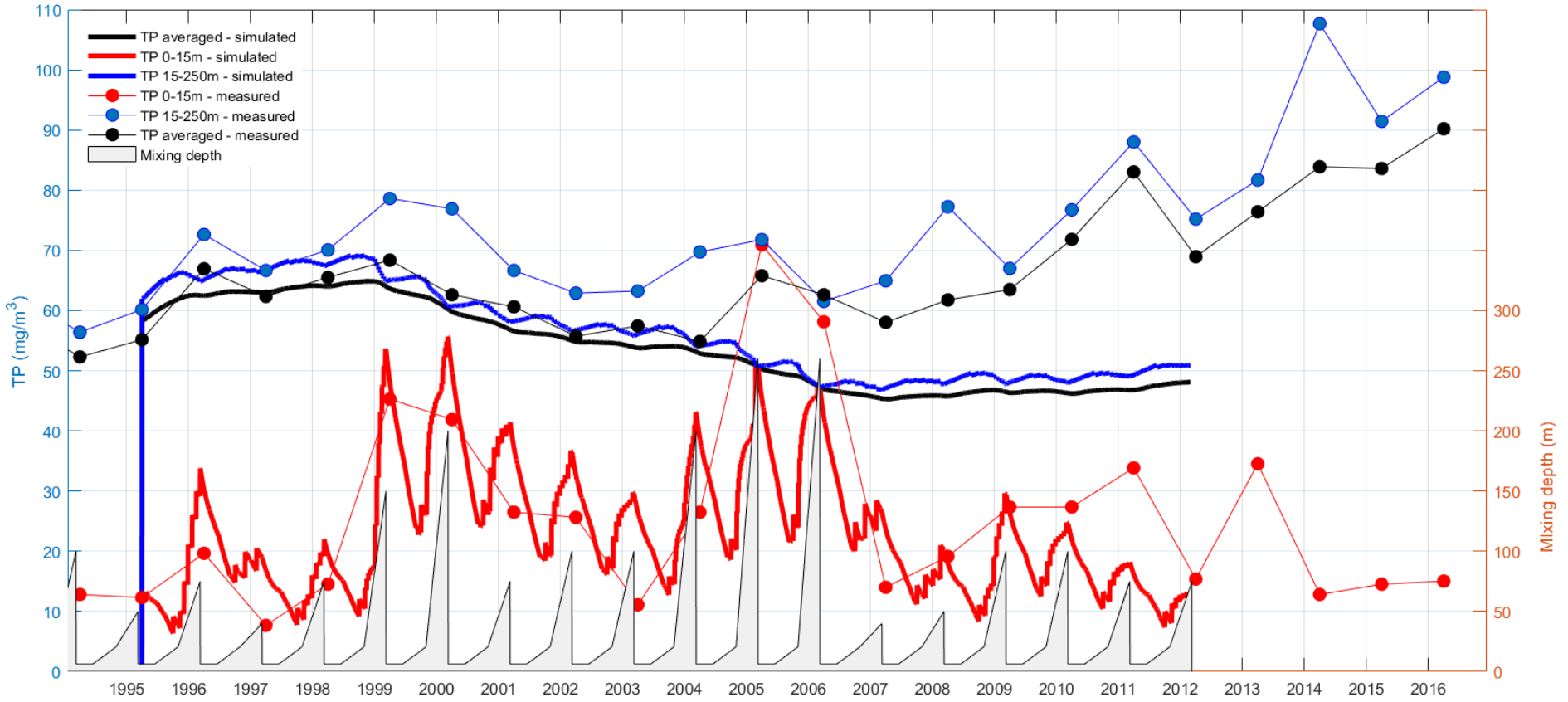




(Master Thesis of Stella Volpini)

Preliminary result: Deep P supported by sediment release and sedimentation; seasonal P trend in the epilimnion that alternates period of enrichment during winter cooling and P decrease due to epilimnion flushing, algae uptake and sedimentation

P data from Rogora et al. 2018



ISEO
Improving the lake Status from Eutrophy towards Oligotrophy

Overview of the dissemination activities carried out by the UNIBS group

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fondazione cariplo

18 June 2019, Brescia

Science communication in secondary schools through limnology

Science communication in secondary schools through limnology

- **Why science communication ?**

Increase scientific competence of youngsters.
Foster citizen science

- Why physical limnology ?

- Why Secondary Schools ?

- How to communicate

- When and who

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- **Why physical limnology ?**
  - **Area of Research and environmental relevance of lakes**
  - **Create interest towards lakes through youngsters genius loci**
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  - **Data manipulation through Spreadsheets and programming**
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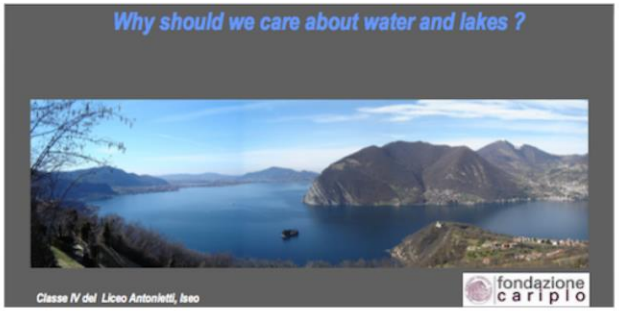
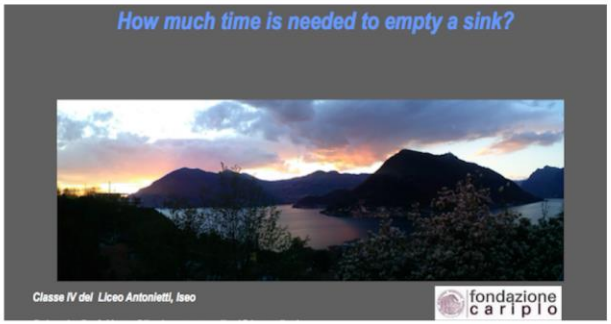
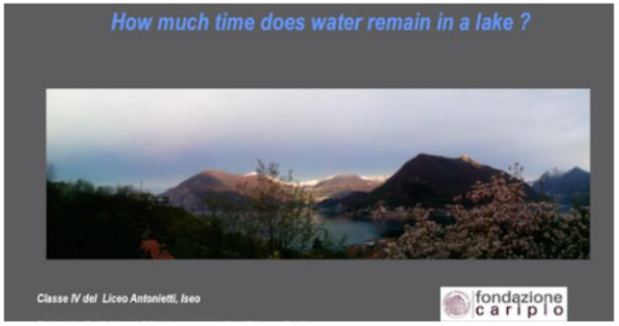
- **When and who**
  - Liceo Scientifico Calini, Brescia;
  - Liceo Scientifico Leonardo, Brescia;
  - Liceo Antonietti Iseo

Science communication in secondary schools through limnology

First Slide of the seminar	Leading Idea	Method	Curricular Competence
	Why water is important	• Analysis of Hydrologic Balance • Statistical analysis of the average water consumption of the students in the class	• natural science • statistics
	Physical law have a predictive power	• Experiments of mass conservation with a simple reservoir • Use of a Spreadsheet	• physics • math
	Simple models must be refined to get the right answer...	• Experiments of pollutant dilution with time in a CSTR	• physics • math

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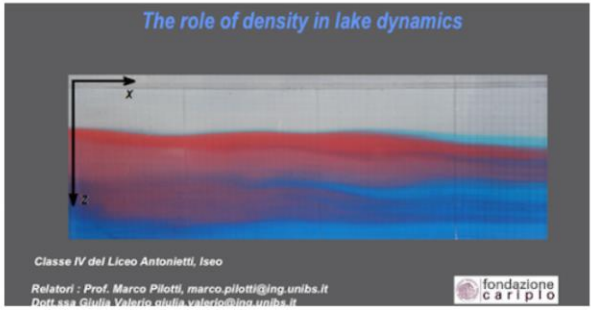


If thermal stratification is at play, the model must be further refined ...

- **Physical model of a stratified lake, with visualization of overflow, intrusion and plunging flow**
- **Internal waves by artificially generated wind**

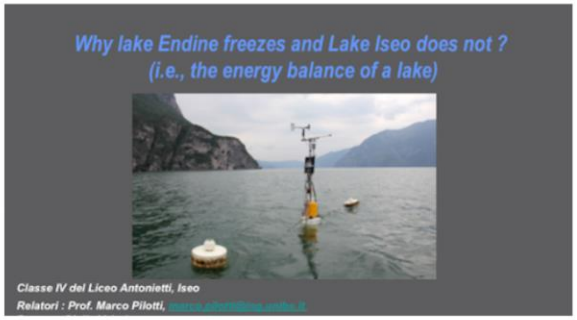
- **physics**
- **math**

Sometimes a spreadsheet is not the easiest way to deal with the problem ...

- **Introduction to the implementation of simple algorithm with a free PASCAL compiler**

  roots of a second order equation
  Cramer's rule for a 3x3 system
  recursive equation for mass conservation

- **algorithmic thinking**
- **math**
- **computer science**



The importance and implication of the energetic balance of a lake

- **hands on working on the data measured by our LDS**
- **Computation of energy balance with a spreadsheet and with a simple code**

- **physics**
- **math**
- **computer science**

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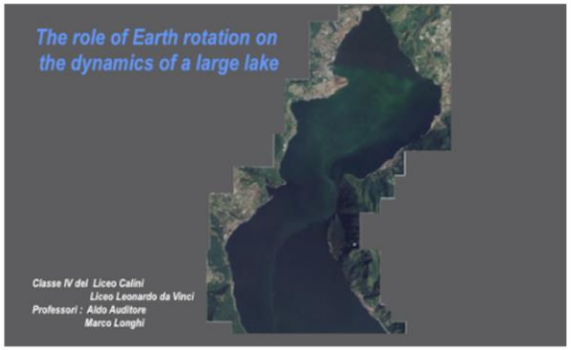

Earth rotation has a role to play...

- Visit to the laboratory at the University
- Physical experiment exploring the role of Coriolis' force on the lake inflows
- Physical experiment on Taylor's columns

- A glance on the world of University and Research

Physics, chemistry and Ecology of a lake are deeply interconnected

- The chemistry of photosinthesys
- The Lotka Volterra Model
- A simple code to solve the Lotka Volterra system of equations

- chemistry
- ecology
- math
- computer science

Is it only Theory ?

- Measurement campaign in lake Iseo
- lake trip to the LDS
  Use of an oceanographic probe
- Use of a Van Dorn bottle
- Use of Secchi disk
- Evaluation of P and N content in deep and epilimnic waters

- Experimental skills in the field

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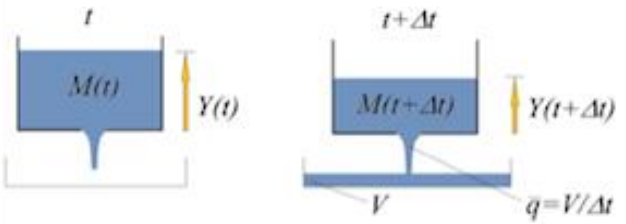
Let us explore the multifaceted reality of the environment where we live

- **Group Assignements on topics selected from a wide list of proposals regarding the lake and the surrounding environment**

- **Group working**
- **All the skills listed above**
- **Set up of a Final Report**
- **Set up of a presentation**

Seminar 2



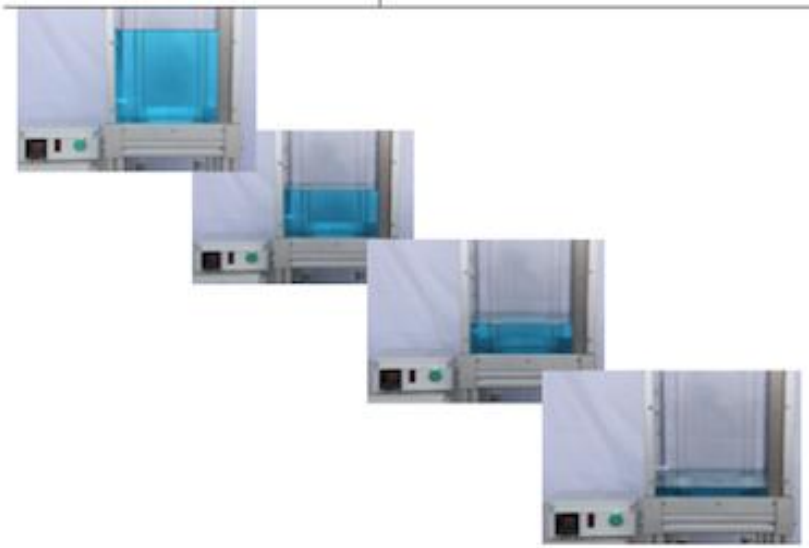
$$M(t) = \rho \cdot A \cdot Y(t)$$

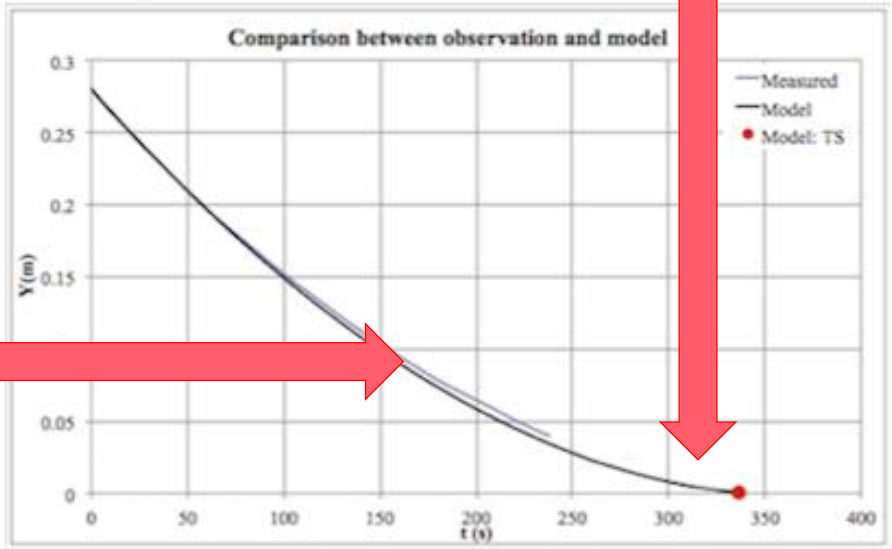
$$M(t) = M(t+\Delta t) + \rho \cdot V$$

$$M(t+\Delta t) = M(t) - \rho \cdot V$$

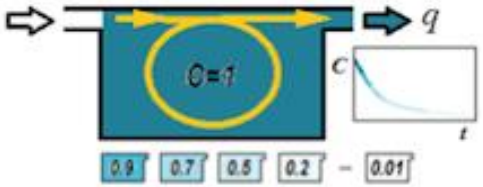
$$Y(t+\Delta t) = Y(t) - \frac{V}{A}$$

$$Y(t+\Delta t) = Y(t) - C\sqrt{Y(t)} \quad C = \frac{a\sqrt{2g}\Delta t}{A}$$





Seminar 3



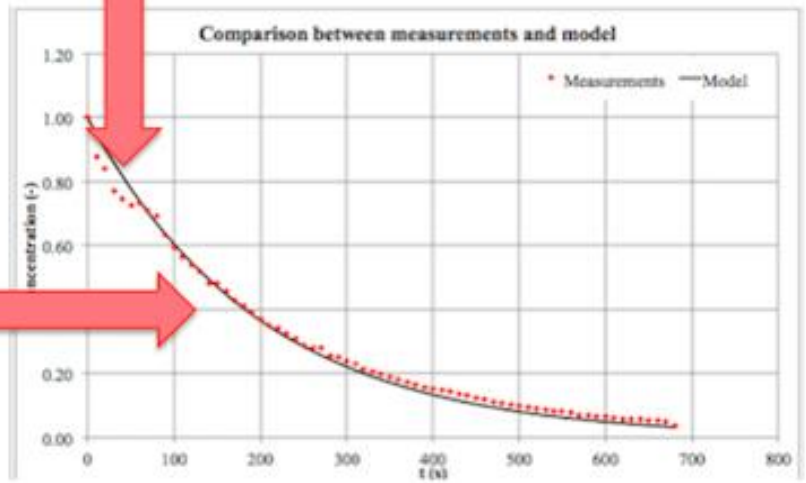
$$C = V/V_L$$

$$V(t+\Delta t) = V(t) - C(t)q\Delta t$$

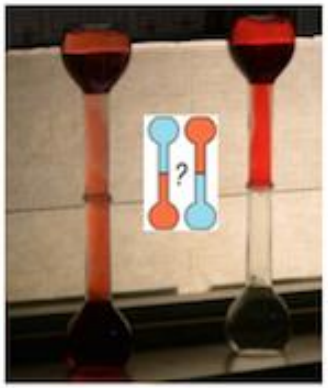
$$\frac{V(t+\Delta t)}{V_L} = \frac{V(t)}{V_L} - \frac{C(t)q\Delta t}{V_L} = \frac{V(t)}{V_L} - \frac{C(t)\Delta t}{T_R}$$

$$T_R = \frac{V_L}{q}$$

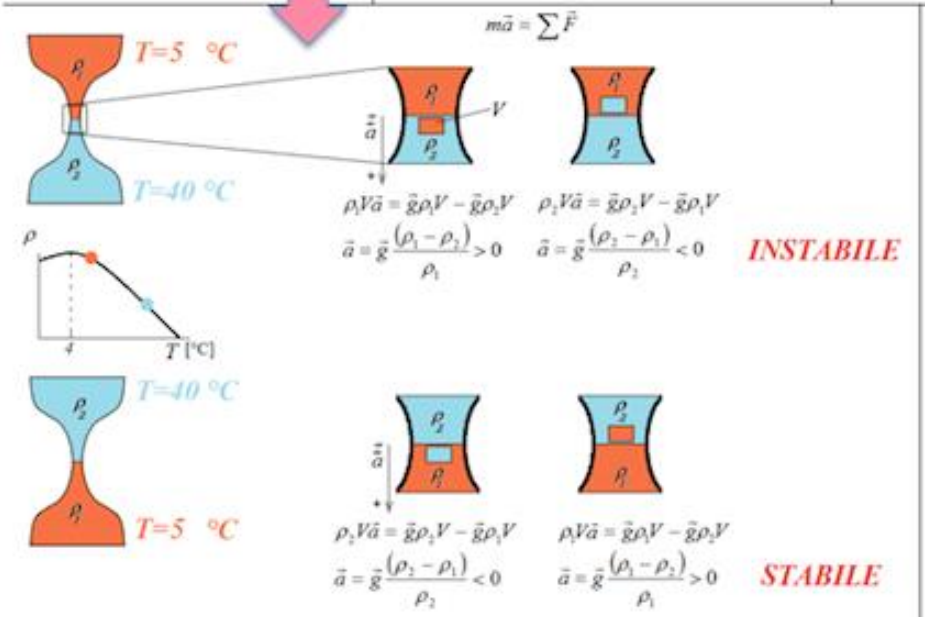
$$C(t+\Delta t) = C(t)(1 - \frac{\Delta t}{T_R})$$

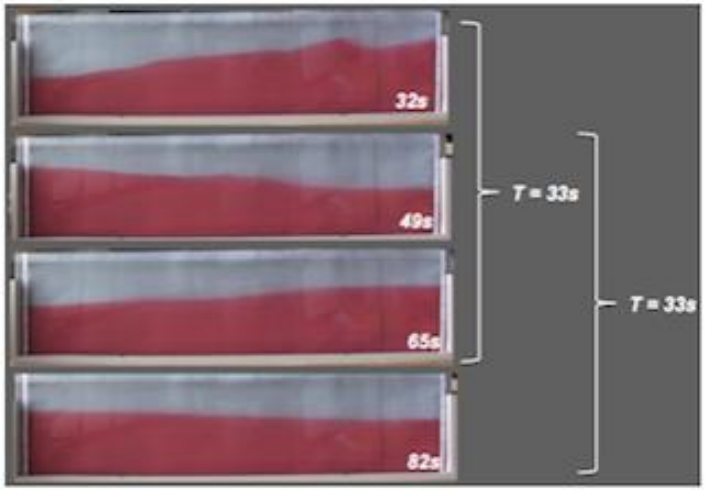


Seminar 4



$$T = \frac{L}{\sqrt{g\,\frac{\rho_2-\rho_1}{\rho_2}\,\frac{h_2 h_1}{h_2+h_1}}} = 30s$$





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Protected: Ciclo seminariale Licei Calini e Leonardo – Brescia

In questa sezione è raccolto il materiale didattico utilizzato nell'ambito del progetto "Il lago, genius loci del territorio bresciano, occasione di introduzione al pensiero scientifico", rivolto agli studenti del liceo Calini e del Liceo Leonardo (anno scolastico 2014-2015) e coordinato assieme ai docenti dei corsi di Fisica e Matematica, Prof. Aldo Auditore e Prof. Marco Pietro Longhi. Questo progetto è cofinanziato dalla Fondazione della Comunità Bresciana Onlus.

- Questionario relativo al consumo_di acqua da completare da parte di ciascun studente
- Seminario_1.pdf
- Presentazione_delle_interviste.pdf
- Intervista a Steven Chapra, Tuft University, Boston
- Intervista a Charlie Hogg, PostDoc, Cambridge University
- Intervista a RobertaFornarelli, Environmental Engineer in Perth, Australia
- Intervista a NinoFrosio, ingegnere, esperto di utilizzo idroelettrico delle risorse idriche
- Seminario_2
- Seminario_3
- Seminario_4
- Seminario_5
- Seminario_6
- Seminario 7 (4/5/2015 con foglio elettronico sottostante)

Materiale di supporto relativo ai diversi seminari

- Elenco delle domande poste durante le interviste e spiegazione di alcuni termini utilizzati
- Mappa delle precipitazioni medie annue in Lombardia
- Report UNESCO sui Flussi virtuali di acqua
- Report USGS sulla misura della conducibilità
- Seminario2_foronomia.xls
- Seminario3_sul tempo di ricambio in un serbatoio.xls
- Seminario 5: fogli elettronici Analisi_dati_temperatura e Bilancio_energetico_giornaliero
- Seminario 6: articolo scientifico sul modello fisico del Lago d'Iseo
- Seminario 7: Foglio di calcolo sulla dinamica delle popolazioni
- Articolo divulgativo sull'eutrofizzazione
- Articolo scientifico sull'eutrofizzazione

Italy	16613 (89 %)
United States	511 (3 %)
Austria	155 (1 %)
United Kingdom	146 (1 %)
Netherlands	82 (0 %)
Germany	82 (0 %)
France	79 (0 %)
Spain	54 (0 %)
China	49 (0 %)

Total Visits: 18393

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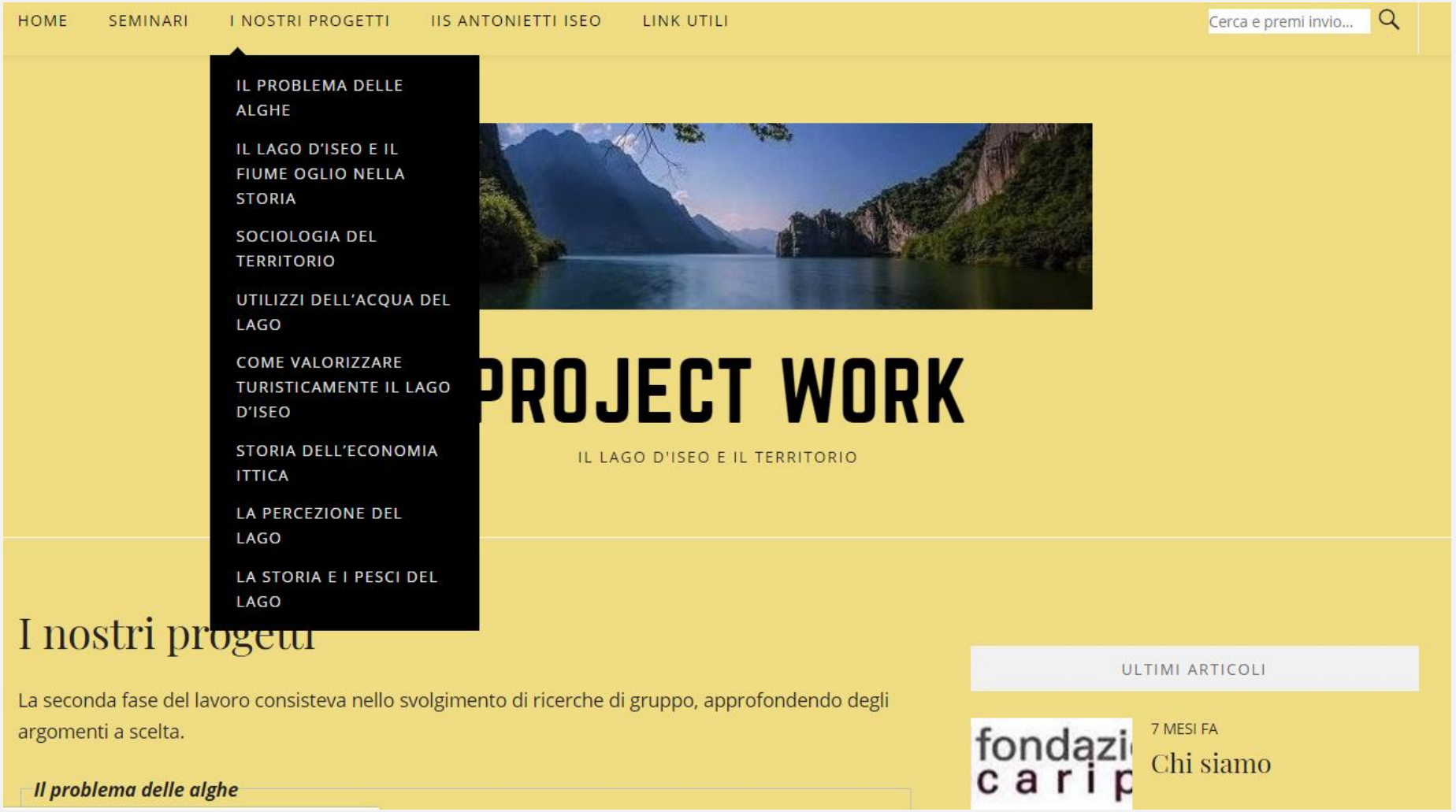
https://aslantonietti1718.altervista.org/chi-siamo/



Discussion

- What about a common paper discussing the methodologies for the measurements of the whole nutrient load to a lake?
- Ideas for future projects?
- ….